

THE YIELD OF MAPLE SAP PER TAPHOLE¹

THE VOLUME OF MAPLE SAP or "sweet water" produced per taphole and the sugar content of that maple sap are of great importance to the sugar bush operator. A knowledge of the yield of sap per taphole would enable the sugar bush owner to more efficiently plan his sirup production from the standpoint of determining the number of buckets to hang, the size evaporator to purchase, the volume of fuel to provide, and the labor necessary to operate the sugar bush.

Unfortunately, there is little accurate data available on the yield of maple sap per taphole or per bucket. The older maple sirup bulletins presented the yields by volume per tree, which has been somewhat confusing as the number of tapholes or buckets per tree varies with the diameter of the tree. The accepted rule is to hang one bucket on trees 10 to 15 inches in diameter, two buckets on trees 15 to 20 inches, three buckets on trees 20 to 25 inches and four buckets on trees over 25 inches in diameter.

The sugar content of maple sap has been ably presented by Taylor (13) who reported from a survey of 4,500 trees that maple trees have a wide variation in the sugar content of their sap. Trees in the same sugar bush may vary as much as 2 to 3 percent in the sugar content of their sap. Taylor (13) also found that a single tree will show variation in the sugar content of sap from one season to the next. However, a tree producing a high sugar content is generally consistently high.

The sugar content of maple sap may be readily determined with the aid of a "Brix" sap hydrometer, or a refractometer. However, a refractometer is too expensive to recommend to the average maple sirup producer. It is possible after repeated tests during a season and successive seasons, to screen all trees in the sugar bush according to the sweetness of their sap, and eliminate the low producers.

To determine the total maple sirup or sugar potential of a taphole, the total flow of sap in pounds or gallons must be known. A taphole producing 3 percent sugar as solids in its sap will produce 3 pounds of sugar for every 100 pounds of maple sap. The simplest method is to use the "Rule of 86" (15). Maple sirup of standard density (65.5 degrees Brix) contains 86.3 percent of solids (as sugar) on a weight volume basis. The density of maple sap being comparatively low, its Brix value and percentage of solids (weight-volume) are essentially the same.

Therefore, the percentage of solids (weight-volume) of the sirup divided by the Brix value of the maple sap equals the number of gallons of sap required to produce 1 gallon of finished sirup. For example, a taphole producing sap of 3 percent sugar (86 divided by 3 equals 28.7) the approximate number of gallons of this sap to produce 1 gallon of finished sirup. Therefore, it is essential to know the yield of maple sap per taphole in gallons, as well as the sugar content, if the sugar bush is to be operated in the most efficient manner.

The maple sap or "sweet water" yield from maple trees was reported at an early date (1885) by Dr. H. A. Cutting (5), when he recorded the gram weights of sap from 15 tapholes for one season. The sap volumes varied from 297 to 77,863 grams per taphole. On the average converted to gallons this would give a yield of approximately 6.5 gallons per hole. Jones, Edson, and Morse (7) in 1903 reported an average of approximately 4.3 gallons, but unfortunately they do not state if this included the entire season's sap flow.

Fox and Hubbard (6) in 1905 reported a yield of 19 gallons of sap per tree during eight consecutive seasons, including one poor season. However, they do not state the number of buckets or tapholes per tree. Collingwood and Cope (4) in 1938 reported the yield per taphole to be 15 gallons, but they present no data as to the number of tapholes, seasons or measurements to support their figure. McIntyre (8) in 1932 reported the yield from over 400 tapholes averaged 25 quarts (6.25 gallons) per hole. Anderson, Ball, Moore and Baker (1) reported yields of 5.35 to 14.03 gallons per bucket for Ohio. Tressler and Zimmerman (14), during a three-year period, reported the yield from 258 tapholes averaged 9.6 gallons.

The author (12), during a three-year study of maple sap flow and weather relationships at the Dunbar Forest Experiment Station, Chippewa County, Michigan, weighed the flow of maple sap from 25 tap-

holes on 25 trees every day of flow and found the average to be 12.8 gallons per taphole.

The author also reported (11) that the yield of sap from 359 tapholes in the Michigan State University demonstration sugar bush at East Lansing, over a five-year period, 1933 to 1938, averaged 9.7 gallons per taphole. Morrow (10) in a study of tree crowns in relation to sap production reported yields of 13 gallons per bucket for trees with typical woods crowns, 16 gallons for trees growing in semi-open conditions, and 24 gallons per bucket for roadside trees. Willits (15), in one of the most complete and recent publications on maple sirup, states the yield per taphole ranges from 5 to 15 gallons.

A maple sap research project to study many phases of maple sirup production was conducted by the Forestry Department of Michigan State University in cooperation with the Eastern Utilization Research and Development Division of the Agricultural Research Service of the U. S. Department of Agriculture, Philadelphia, Pennsylvania. It afforded an excellent opportunity to accurately determine the flow of maple sap and the sugar content of the sap from individual tapholes.

The trees tapped in this project are located in one of the sugar maple woodlands on the university campus. The "Baker" woodland of 70 acres was selected in preference to the 55 acre "Sanford" sugar bush, which has been operated as an experimental and demonstration sugar bush since 1915, because the trees in the "Baker" woodland had never been tapped. Therefore, this woodland would give data which could not be influenced by previous tapping operations. The trees were tapped for the first time in February 1953, during the 48-hour period before the first sap run. This is forecast to the Michigan maple sirup producers by the Michigan Section of the U. S. Weather Bureau and the Forestry Department of Michigan State University over radio station WKAR.

All maple sap was weighed to the nearest tenth of a pound during every day of flow, and the sugar content of the sap was taken at the same time with a hand refractometer. All measurements were transferred to IBM cards and the summaries were produced by the machines.

Table 1 presents the data on year of tapping, number of trees tapped, number of tapholes, total yield in gallons for the season, yield per taphole, average sugar content of the sap and the yield of sugar in pounds, and the total number of weights taken on which the yields were based. Only the tapholes, which were not influenced by other

TABLE 1—Number of trees, tapholes, yields of sap and sugar per taphole, and number of weighings

Year	Trees tapped	Number tapholes	Total yield gal. sap	Yield taphole gals.	Av. sugar content of sap	Yield pounds sugar taphole	Basis no. of wts.
1953.....	72	120	1,713	14.3	2.98%	3.5	2,802
1954.....	72	120	2,750	22.9	2.19%	4.2	4,755
1955.....	122	170	3,612	21.2	1.88%	3.3	5,419
1956.....	102	150	2,674	17.8	2.40%	3.5	4,635
Four year average.	92	140	2,687	19.05	2.38%	3.62	4,403

treatments conducted during the project, were used for the data in Table 1.

The four-year average yield of 19 gallons of maple sap per taphole as given in Table 1 is considerably greater than the yields reported by Jones, Edson and Morse (7) of 4.3 gallons of sap; Collingwood and Cope (4) of 15 gallons; McIntyre (8) of 6.25 gallons; Anderson, Ball, Moore and Baker (1) of 5 to 14 gallons; Tressler and Zimmerman (14) of 9.6 gallons; Morrow (10) of 13 gallons for woods trees; and the author (11) of 9.7 gallons of maple sap per taphole.

This good yield of 19 gallons per taphole for four seasons with an average sugar content of 2.38 percent, if converted to maple sirup by the "Rule of 86" would require only 36 gallons of sap to produce 1 gallon of finished sirup, i.e., (86 divided by 2.38 equals 36.1). Therefore, this yield would produce approximately $\frac{1}{2}$ gallon of maple sirup per taphole, which is more than double the yields of maple sirup per taphole (0.12 to 0.27 gallons) previously reported by the author for 14 seasons (12). It is also greater than the 0.32 gallons of sirup per bucket for woods trees as reported by Morrow (10).

This yield of 3.62 pounds of sugar per taphole as given in Table 1 is greater than the maximum reported per tree for any one year of 30 years of maple sirup crop reporting (16) by the Bureau of Agricultural Economics, Crop Reporting Board, U. S. Department of Agriculture.

This high yield demonstrates the potential production of maple sirup possible from a managed woodland which has never been pastured and one that has received periodic harvest and improvement cuttings aimed primarily for the production of lumber.

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